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ABSTRACT

Effects of mobilizing prior knowledge on information processing were studied with 3 groups of 12 adult subjects each. The assumption that activating different kinds of prior knowledge would induce different information processing activities during subsequent text processing (inferencing or elaborating) was tested using passages about fishing policy or tourism in the European Economic Community. It was hypothesized that inferences are induced by activating prior knowledge that could have evolved into a schema through experiences in a particular domain, and that they instantiate the schema. Elaborations, on the other hand, would result from activating limited prior knowledge, represented in an associative network. Elaborations would be required during subsequent text processing to bridge gaps between conceptual nodes in the text and nodes in the associative network. Findings suggested that inferences were mostly drawn when the activated prior knowledge had evolved into a schema, but elaborations were most frequent when limited prior knowledge was activated, represented in an associative net. Appendixes contain a sample passage, and an analysis of responses to the passage. (Contains 2 tables and 17 references.) (Author/SLD)

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The Relation Between the Nature of Prior Knowledge Activated and Information Processing: To Elaborate or To Infer?

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Abstract

Effects of mobilizing prior knowledge on information processing were studied. In this article the assumption is tested that activating different kinds of prior knowledge would induce different information processing activities during subsequent text processing: inferencing or elaborating. It is hypothesized that inferences are induced by activating prior knowledge that could have evolved into a schema through innumerable experiences in a particular domain. Drawing inferences would boil down to filling slots of the activated schema in order to instantiate it. Elaborations, on the other hand, would result from activating limited prior knowledge, represented in an associative network. Elaborations would be required during subsequent text processing to bride gaps between conceptual nodes in the text and nodes in the associative network. The initial network can become extended by integrating these elaborations, which are often based on knowledge from other domains.

The paradigm applied, information processing activities, provided support for the assumption that activating prior knowledge of different levels (schema versus associative network) might induce different information processes.

The Relation Between the Nature of Prior Knowledge Activated and Information Processing: To Elaborate or To Infer?

The past fifteen years, the study of text comprehension has been dominated by the schema-theoretic approach (Rumelhart & Ortony, 1977; Schank & Abelson, 1977). Reading a text is assumed to activate a relevant schema, which, in turn, guides text processing in a top-down fashion. A schema can be described as a cognitive structure, containing information abstracted from situations or events frequently experienced (Anderson, 1990). These knowledge structures contain slots in which information from real world experiences or from their textual representations can be inserted. Comprehension is, therefore, in the schema-theoretic view primarily a process of instantiating an appropriate schema. But what if no ready-made schema is available for comprehending new information, a situation quite common in most natural learning settings since the very idea of schooling is that students learn things that may be entirely or largely new to them. Kintsch (1988) acknowledged this critique in his construction-integration model, based on bottom-up information processing. Existing knowledge of the world is represented by an associative network of nodes and interrelations, the knowledge base. Such a network is far more flexible than a schema since its concepts (or propositions) are loosely interrelated. While studying a text, words in this text will activate corresponding nodes and activation will spread to related nodes. In this way, a pool of knowledge is activated that may or may not be relevant to the task of understanding the text at hand. The irrelevant knowledge activated in this construction phase is constrained by more information from the text and, hence, activation of further concepts and interrelations. Thus, in this integration phase

a coherent text representation is formed by integrating knowledge from earlier activation cycles with that of later cycles, resulting in a text base. To create such a coherent text base, missing links may have to be produced based on pre-existing knowledge. Thus, the meaning of a text is an integration of existing prior knowledge and information from that text; in this way, the initial knowledge base is extended.

These rather different notions about the way in which knowledge is represented were recently incorporated in one theory about knowledge acquisition (Schmidt & Boshuizen, 1992; Shuell, 1990), which roughly can be characterized as the development from novice to expert. In the first phase of meaningful learning, the learner is not yet familiar with the knowledge domain. During information processing he acts like a novice since specific domain knowledge is still lacking. Isolated facts are memorized; existing knowledge structures of other domains are applied to interpret the new information. The newly acquired information is bound to the specific context in which it was encountered. Gradually, an overview of the new domain's content arises. In this intermediate phase, relationships are built between the isolated information pieces, acquired in the initial learning phase. Eventually, the knowledge becomes more abstract since it is applied to all kinds of situations. Thanks to this generalization, the knowledge becomes less dependent on the context in which it was obtained. During the final phase the knowledge structures become more integrated and work more automatically; thus, the state of schema has been reached. Mastering tasks (e.g., solving problems) will be effortless and automatic. In this phase, learning consists of adding new facts to the existing cognitive structures or acquiring higher levels of interrelationships between elements of this cognitive structure.

The hypothesis that activating knowledge of different levels in this continuum could result in divergent information processing

strategies was confirmed by means of both recall data and patterns of study time allocation (Machiels-Bongaerts, 1993; Machiels-Bongaerts, Schmidt, & Boshuizen, 1990, 1991, 1993). The purpose of the present study is twofold. First, to provide additional support for this hypothesis by means of a third paradigm: information processing activities. Second, to unravel the terms "inference" and "elaboration", which we consider as two different information processing activities, but which are often used as synonyms in both educational and cognitive psychology. These information processing activities have in common that they are based on pre-existing knowledge, in this way meeting one of the prerequisites for meaningful learning (Mayer, 1987). It is hypothesized that these information processing activities are founded on prior knowledge of different levels in the knowledge acquisition model.[1] In our opinion, inferences are based on prior knowledge that could have evolved into a schema, owing to innumerable experiences in a particular domain. Drawing inferences would thus boil down to filling slots of the activated schema in order to instantiate it (Oakhill, 1983).[2] Elaboration, on the other hand, would occur if limited prior knowledge is activated, represented in an associative net. According to Levin (1988), "... elaboration involves the addition of meaning to enhance comprehension, learning, and/or memory" (p. 200).

In summary, the keyword in inferencing, typical for an expert, is "integration". Through many experiences and applications of this knowledge, the state of schema has been reached. Schema activation results in the availability of all slots, which merely have to be filled with appropriate information. The schema is instantiated by integrating this information from the study text. The keyword in elaborating is "extension". A novice's knowledge is still limited, consisting of a set of concepts and their interrelations. Such a net will

contain many loose ends, while some of them have not yet been validated. Activating this type of prior knowledge will often result in difficulties interpreting new information. Frequently no links will exist between textual concepts and nodes in the associative net. Elaborations, often based on knowledge from other domains, have to bridge these gaps. The initial network can be extended by adding these elaborations.

Method

Subjects

Three groups of twelve subjects each participated in this study. The EEC group had to orally generate (mobilize) all knowledge about the EEC fishery policies and their consequences. These policies were in the news quite often when this study was carried out. Possibly because of that, EEC subjects were able to activate quite some knowledge on the subject-matter, however, without showing any signs that this knowledge already had a schematic structure (Machiels-Bongaerts et al., 1991). Since the EEC subjects activated non-schematic knowledge, they were expected to primarily produce elaborations. The tourism group had to mention as many factors as possible that would be important for a tour operator who had to decide whether a location would be apt as a new holiday resort. By means of this task, a holiday schema was activated[3]; consequently, tourism subjects were expected to mainly draw inferences. The control group mobilized knowledge about a neutral topic (tennis).

Material

The study text (Appendix I) described the effects of the EEC's restrictive fishery policies on a small imaginary fishermen's village in

Portugal. The text outlines these policies, including limited fishing quota for member countries, and describes their effects on the village's faltering economy. This EEC information corresponded with prior knowledge activated by the EEC group. The text proceeds with a possible way of dealing with the consequences of these policies: establishing a fish-farm. This fish-farm information was fabricated by the experimenters; so none of the subjects had any knowledge of this topic. Both the EEC and the fish-farm information were important in the text's hierarchical structure (Appendix II). Throughout the text references are made to the natural beauty of the village, implicitly showing its potential as a future holiday resort. This tourism information was rather redundant in the text itself; yet, it would fill slots of the tourism group's schema. Each information category consisted of ten sentences or 22 propositions. In order to build a coherent text, 27 short filler sentences were added; this residual information contained 34 propositions.

Procedure

After prior knowledge mobilization, each subject studied the text closely in order to recall as much as possible of the entire text. The 57 sentences of the text were presented one by one on a computer screen. Subjects were free in the amount of time spent on each sentence; study time was registered. After a 20-minute distraction task, subjects had to report orally everything they could recall of the text.

Scoring and Analysis

The 36 recall protocols were transcribed; twelve protocols were randomly selected and scored by a second rater (mean interrater agreement 84%). For each subject, the number of inferences and

elaborations per information category was established. Our classification criteria might be elicited by the following examples:

Text (Tourism information)	Inference
The average temperature in the summer amounts to 25 degrees and in the winter to 16 degrees.	Crando Douro has a mild climate.
Text (EEC information)	**Elaboration**
The illegally caught fish is confiscated.	I assume that the confiscated fish will be withdrawn from the market, which is a shame regarding the starvation in the Third World, but, hey, that also holds for the Dutch butter mountain.

Results and Discussion

Table 1 presents the number of inferences per information category for each group (SD's between brackets).

Insert Table 1 about here

The three groups differed in mean number of inferences, F (2, 33) = 124.093, $p < .0001$. Newman-Keuls comparisons (alpha set at .05) showed that, as predicted, the tourism group outperformed the other groups in this respect. The mean number of elaborations, presented in Table 2, also differed for the three groups, F (2, 33) = 35.684, $p < .0001$.

Insert Table 2 about here

Newman-Keuls comparisons showed that in this respect the EEC group excelled.

In line with our expectations was the finding that the tourism group's inferences were largely based on tourism information; this number exceeded the number of inferences made for EEC ($t(11) = 17.234$, $p < .0001$), fish-farm ($t(11) = 13.619$, $p < .0001$) and residual information ($t(11) = 17.11$, $p < .0001$). The EEC group's elaborations, on the other hand, were equally distributed over the EEC and the fish-farm information ($t(11) < 1$), each exceeding the number of tourism or residual elaborations.[4] Thus, not only the type of information processing activities is in line with our predictions, but also the category of information for which they were made. As a result of activating a holiday schema, the tourism group mainly drew inferences with respect to slot-filling tourism information. Owing to activating an associative net, corresponding with the EEC information, the EEC group mainly made elaborations with respect to this information and new, important fish-farm information that could extend the initial limited knowledge.

To be complete: The patterns of recall and study time allocation confirmed previous findings (Machiels-Bongaerts, 1993). Newman-Keuls comparisons showed that, under this study time condition, the EEC group as a result of activating prior knowledge required less time overall than the control group to obtain similar recall scores. The control group was able to compensate its processing disadvantage, due to lack of activating relevant prior knowledge, by spending more time on the text; consequently, the control group's overall recall could equal the EEC group's. Remarkably, however, the EEC group did outperform the control group in number of elaborations, implying that activating prior knowledge, represented in a loosely interrelated net does induce

a different way of information processing which goes beyond time-saving effects. The tourism group displayed patterns of study time allocation and recall quite divergent from those of the other two groups. Tourism information had been focused during the study phase since only this information corresponded with slots in the activated schema; consequently, recall of tourism information was superior.

In conclusion: The new paradigm, information processing activities, provided additional support for the assumption that activating prior knowledge of different levels (schema versus associative network) might induce different information processes. Inferences are mostly drawn when the activated prior knowledge has evolved into a schema through many experiences and applications of this knowledge; the goal of this information processing strategy is schema instantiation. Elaborations, however, are most frequent if limited prior knowledge is activated, represented in an associative net; the goal of these information processing activities is extension of the limited knowledge by enriching it with elaborated memory traces (Anderson & Reder, 1979).

The relation between the nature of the prior knowledge activated and information processing activities like inferences and elaborations should be further investigated. It can be deduced from the model of knowledge acquisition that inferences would largely be drawn during encoding, whereas elaborations would mainly be made during retrieval. Inferencing would require a minimum of cognitive effort since the schema slots are already available. Elaborating, though, would require much cognitive capacity since links have to be established between the new information and pre-existing knowledge by means of laborious reasoning.

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Appendix I

The Consequences of the EEC Fishery Policies for Crando Douro[5]

Since 1986, the EEC fishery policies are also in force for Portugal, which has led to an unemployment rise in many small fishing-villages (R). Due to the fish catch limitations the income dropped, which increased unemployment (R).

This holds, for instance, for Crando Douro with less than 14,000 inhabitants, located at the mouth of the Douro; this village is largely dependent on fishing since many generations (T). It is not only because of its climate - the average temperature in the summer is 25 degrees and 16 in the winter - that this picturesque village is suited for this trade, but there is practically no alternative profession for the inhabitants due to lack of education (T).

The unemployment has enormously increased as a result of the EEC measurements (R). In 1986, the total amount of catch allowed for Crando Douro added up to 60,000 tons only, forcing the fishing-industries to cut back their concerns and to fire a large number of fishermen (R).

There are practically no prospects for the population since there is hardly any industrialization in the environment (R). But although the existing situation offers little perspective, the inhabitants of Crando Douro are too dignified to accept their fate (R). It does not suit their mentality to live on unemployment benefits and to spend their gained spare time taking walks in the forest or lying on the beach (T).

As a consequence of the increase in unemployment, people are already inclined to move to the city, which will irrevocably lead to an ageing of villages like Crando Douro (R). Especially youngsters are ready to move to the big city (R). In the romantic Crando Douro only

old people and women stay behind, still mastering the old crafts of producing the well-known pottery and needle-point works (T).

Although the EEC fishery policies have caused many problems, even for the people in Crando Douro it is evident that regulation by a co-ordinate institution was necessary (E). In this way overfishing can be avoided; in other words, the extent of the fish population diminishes due to a too intensive catch, which could lead to many fishing-industries going bankrupt (E).

The information above shows that the EEC measurements do not solely serve to preserve the extent of the fish population, but also to protect the fishery-industries of the EEC nations (E). For instance, fishing-industries of non-members are no longer allowed to fish within a 200-miles zone, which should reduce the competition drastically (E).

Since 1977, one of the EEC's tasks is to give a definite decree of the allowed amount of catch and to distribute these so-called "quota" over the member states (E). These quota or Total Allowed Catch, in short TAC, are minutely specified by the EEC regarding fish breeds and catch areas, and always apply to restricted fishing seasons (E). Based on its research, the International Council for the Exploration of the Sea gives the EEC recommendations with respect to the tolerable maximum fish quota (E).

The various EEC guide-lines and regulations are supervized by the General Inspection Service of the Ministry of Agriculture and Fisheries (E). The General Inspection Service severely penalizes illegal fishing; in other words, to continue fishing even if the national quotum, accorded by the EEC, has already been caught (E). The illegally caught fish is confiscated and the fishermen warned, besides being penalized severely, that a repetition of this offence will lead to an arrest (E).

The question remains whether the fishermen of Crando Douro and the surrounding area, who have already been confronted with the measurements of the General Inspection Service, will obey the EEC regulations in the future (R). They want to support themselves even in this hopeless situation (R).

There are two potential solutions for Crando Douro's problems (R).

The first solution is to initiate industrialization (R). In the near future, the Portuguese government tries to attract a number of foreign industries, which should settle at the west coast (R). The government of Portugal, the poorest country in Europe, wants to persuade these multinationals by means of the low value of the escudo and the huge market of cheap workmen (T).

The second solution is to start a fish-farm, for which the power-station at the Douro would be well-suited since the temperature of the cooling water is approximately eight degrees higher than the sea's (F). Fishes which are cold-blooded, as everybody may know, digest their food considerably faster in water with a tropical temperature, which increases growth substantially (F).

Under normal circumstances, it takes ten months for a fish to grow ten centers, whereas in warm water it takes them half that time (F). As a result of this dynamic increase in growth, the production, and thus sales, could almost be doubled while the costs would remain relatively low (F).

In order to establish an optimal growth process, a constant water temperature and an ideal oxygen level are the most essential prerequisites (F). The temperature can be ruled to one degree exactly by mixing cooling water and regular water; the oxygen level can be controlled by means of simple equipment (F). An unnegligible side-

effect of the constant water temperature is that the probability of disease germs to develop in the basins would be considerably reduced (F).

An example of this renewed method of breeding is located in Genk, Belgium, where this modern technique has been successfully applied since several months (F). Besides the well-known trouts and carps, especially tropical Tilapias are cultivated in the Belgian basins, which appear to be well-suited for this way of fish breeding (F). The Tilapia, which is also often referred to as "the fish of the future", comes from Africa and is considered as an exclusive delicacy in the coastal region of the South of France (F).

Apart from the advantages which hold for the alternative solution described earlier as well as for the solution proposed by the government, a number of disadvantages can be pointed out which are of great importance (R).

With respect to the first disadvantage, which is the inadequate infrastructure, the state is willing to meet the multinationals halfway by approving an extension of the road-system (R). This financial contribution has been justified by the Portuguese government with the argumentation that this investment could in the long run be compensated for by reduction of social expenses, which would be the result of the employment created (R). At this very moment, however, this concession would affect the already weak financial position of Portugal (R).

Naturally, the inferior condition of the infrastructure is also an obstacle for the second approach of the unemployment problem in this area (R). However, in this case a cheaper solution could be passed, namely transport by water since the largest fish market is situated in France (R).

The tradition of fishing in Crando Douro would be preserved, thanks to this solution (R). The ancient character of this village with

its market stalls, restaurants serving local dishes, pavements and "estalagens" (little inns) could be saved after all (T).

In the meantime, an extension of the future perspectives could be realized, while the centuries old traditions would not disappear (R). The people are faithful to tradition, which is shown by the fact that they hold on to the traditional bull-fights in which the bull is not killed in the arena, contrary to the Spanish bull-fights (T).

Another ponderous aspect concerns the environmental pollution that comes along with industrialization (R). If the chemical industries dumped their waste materials in the sea, this would form an increasing threat to the already diminishing fish stock (R).

Not only would the chance of a fish stock restoration decline, but the EEC fishery policies, causing so many problems in Crando Douro and the surrounding areas, would also be pointless (R). Water sports like swimming, deep-sea diving, surfing and sailing, for which the Portuguese coast is ideal, could no longer be practiced due to the pollution (T).

In short, industrialization does not seem to be the right answer neither for Crando Douro nor for Portugal (R).

If the Portuguese government still chooses this alternative, the population of Crando Douro has an extra reason to strike up one of their elegies (R). The population's grief is expressed in the "saudades", songs so characteristic for this region and often heard in the small pubs in the harbour - there are no discotheques in Crando Douro (T).

Finally, they can take a pilgrimage to the neighbouring Fatima, where they can pray to God for a miracle in the medieval church with its unique quarrels (T).

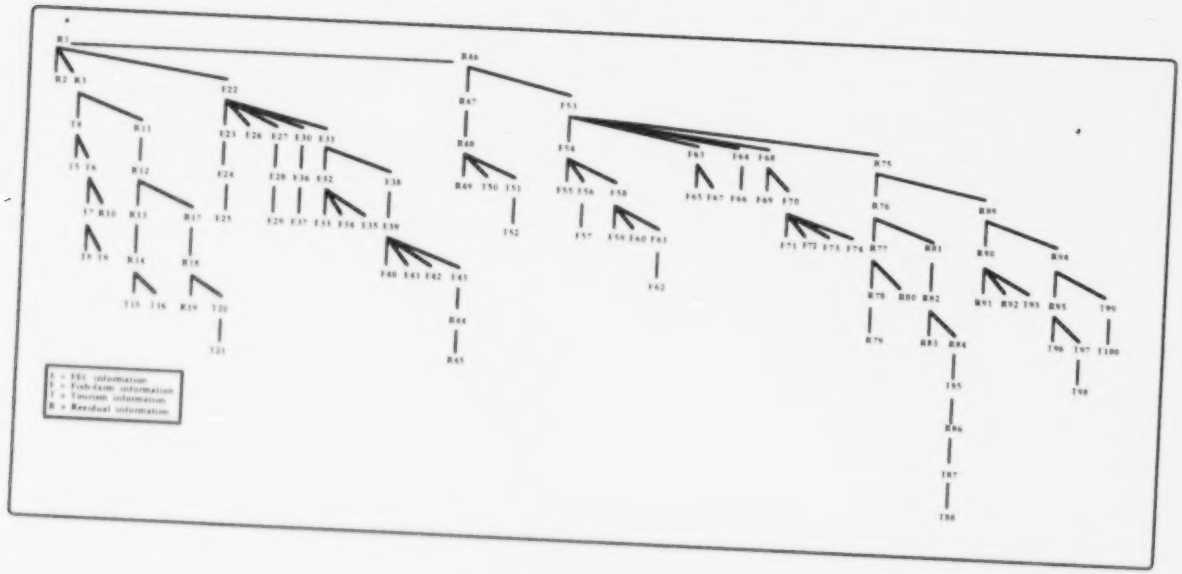
Appendix II

The Dutch version of the text "The consequences of the EEC fishery policies for Crando Douro" contained 57 sentences, consisting of 100 propositions. The EEC information, the fish-farm information and the tourism information were each described in ten sentences, divided into 22 propositions. The residual information contained 27 sentences, consisting of 34 propositions.

Meyer's (1975) method was applied to establish the relations between propositions. It should be pointed out that Meyer's system is more refined than the one applied in these studies. Like Schmidt (1982), a less detailed classification was chosen to simplify the practical application.

The mean level of the EEC information was 4.23 (ranging from level 2 to level 6). The mean number of words, syllables and characters per sentence were 27 words, 52 syllables and 178 characters.[6] The mean level of the fish-farm information was also 4.23 (ranging from level 2 to level 6). The mean numbers of words, syllables and characters per sentence were 27 words, 52 syllables and 178 characters. The tourism information's mean level was 6.63 (ranging from level 3 to level 11). The mean numbers of words, syllables and characters for this information category were 28, 51, and 179 respectively. The mean level of the residual information was 5.17. The sentences of this information category were shorter than the sentences of the remaining information categories; the mean number of words was 16 for this information category.

The text's hierarchical structure is presented on the next page.



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Author Notes

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Footnotes

[1] Except for Graesser and Clark (1985), the relation between information processing activities, like inferencing, and type of pre-existing knowledge has rarely been investigated.

[2] Thus, inferencing does not equal resolving anaphoric pronouns, but goes beyond the sentence level.

[3] The prior knowledge activated by the tourism subjects hardly differed from the elements, characterized as typical for a tourism schema by both Barsalou (1991) and Figler, Weinstein, Sollers and Devan (1992).

[4] The number of EEC elaborations exceeded both the number of tourism ($t(11) = 7.386$, $p < .0001$) and residual elaborations ($t(11) = 3.924$, $p < .01$); the same holds for the number of fish-farm elaborations (($t(11) = 5.989$, $p < .0001$) and ($t(11) = 3.4$, $p < .01$), respectively).

[5] The character between brackets after each sentence indicates the information category to which that sentence belonged. "E" stands for EEC information, "F" for fish-farm information, "T" for tourism information, and "R" for residual information.

[6] It should be pointed out that these notions refer to the original text version.

Table 1.

Mean number of inferences made per information category as a function of mobilization treatment.

	Information category				
Mobilization treatment	EEC	Fish-farm	Tourism	Residual	Totals
EEC group	.333 (.49)	.417 (.52)	.667 (.49)	.167 (.39)	1.583 (.79)
Tourism group	.167 (.39)	.750 (.45)	4.667 (.78)	.750 (.45)	6.417 (1.17)
Control group	.167 (.39)	.500 (.52)	.250 (.45)	.000 (.00)	.917 (.79)

Table 2.

Mean number of elaborations made per information category as a function of mobilization treatment.

	Information category				
Mobilization treatment	EEC	Fish-farm	Tourism	Residual	Totals
EEC group	2.42 (.97)	2.67 (1.44)	.17 (.39)	1.25 (.45)	6.50 (2.32)
Tourism group	.17 (.39)	.42 (.52)	.50 (.52)	.58 (.52)	1.58 (.79)
Control group	.75 (.62)	.67 (.49)	.00 (.00)	1.00 (.85)	2.42 (.97)